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Reaction of Small-Grain Varieties to Green Bug Attack¹

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THE green bug (*Toxoptera graminum* (Rond.)) is a member of the aphid, or plant louse, group of insects, which attack a wide range of host plants. Several members of the group may attack small grains, the more important being the green bug, the English grain aphid (*Macrosiphum granarium* (Kby.)), the apple grain aphid (*Rhopalosiphum prunifoliae* (Fitch)), and the corn leaf aphid (*Aphis maidis* Fitch). In the southern part of the middle western winter wheat belt of the United States the green bug often attacks the small-grain crops in fall or early in spring, spreading rapidly from infestation centers and finally dispersing widely as the winged forms appear in spring.

Damage to the small-grain crop is caused by the insects sucking the plant juices, which results in a yellowing of the leaves. In heavy infestations the leaves soon wither and the plants die, whereupon the insects move to new plants at the edge of the infested area. This results in definite spots of dead plants in the early stages of infestation. Later, as the winged forms appear, the insects scatter and the damage may become more general. Destruction of these early infestation spots by burning straw on them, or plowing them under, offers some measure of control in the early stages, but once infestation becomes general no known control is effective or practical. Under such conditions the only controls are through natural agencies — parasites, predators, and unfavorable weather.

It is the purpose of this bulletin to record some of the factors responsible for the widespread serious infestation of the green bug in

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Texas and Oklahoma in 1942, and to bring to the attention of other workers the reactions to it of some varieties of small grain, especially the high resistance to attack observed in certain barley varieties, some of which may be useful in breeding desirable adapted varieties that are resistant. It may be summarized as follows.

SUMMARY

A severe attack of the green bug caused widespread damage to barley, oats, and wheat in central Texas, Oklahoma, and southern Kansas in the winter and spring of 1942. The damage in Texas and Oklahoma is estimated at more than 61 million bushels of grain, valued at current prices at more than 38 million dollars. Oats and barley were damaged more severely than wheat and over a larger area.

Opportunity was afforded to observe varietal resistance in wheat, oats, and barley on a more extensive scale than has been previously reported. These included observations at Denton and Chillicothe, Tex., and Lawton, Okla., where extensive experimental plantings were grown.

Under heavy infestations at Denton and Chillicothe, the most resistant strains of wheat were selections from the cross Marquillo \times Oro, which are also resistant to the hessian fly. These strains were developed by the Kansas Agricultural Experiment Station. Other wheats showing some resistance included Denton, Early Blackhull, Wichita, Blackhull and Blackhull crosses, and several Chinese and Russian strains, but none of these appears to have sufficient resistance to withstand heavy attack.

A considerable number of barley varieties, mostly from the Orient (chiefly China and Chosen), showed very high resistance to attack, surviving and maturing a crop when all surrounding strains were killed. Several other strains that originated from crosses on oriental barleys also showed high resistance. Bulk hybrids growing at Denton showed resistance among the segregates when one parent included was a resistant strain, suggesting that the resistance of these strains can be transferred to adapted varieties by crossing.

Among the oat varieties and strains there were included most of the commercial red oat varieties and hybrid strains. None showed outstandingly high resistance, although some differences in susceptibility were observed at Lawton. Wintok, a common winter oat, was much more susceptible to attack than the varieties Fulwin and Tennex. Further testing of oat varieties from world-wide sources is needed before any conclusions regarding resistance can be made.

REVIEW OF LITERATURE

The first reported specimens of the green bug in the United States were found in 1882, according to Webster and Phillips (11).² The first general outbreak was in 1890, when damage to small grain occurred in Texas, Oklahoma, Indiana, Illinois, Kentucky, and North Carolina. In 1901, an outbreak occurred in central Texas and spread from McLennan County northward through Oklahoma and into southern Missouri, causing an estimated damage of several million dollars. Probably the most widespread and serious outbreak was in 1907. It started in central Texas, spreading into a fan-shaped area extending northward through Oklahoma, Kansas, Missouri, Arkansas, and into Illinois to within 60

²Italic numbers in parentheses refer to Literature Cited, p.30.

miles of Chicago. Damage was reported the same year from North Carolina and South Carolina. Walton (10) estimated the loss in the outbreak to exceed 50 million bushels of grain. In Texas, 70 percent of the wheat acreage was abandoned.

An outbreak in Kansas and Oklahoma in 1916 caused an estimated loss of 600,000 acres of oats and 260,000 acres of wheat, according to Kelly (6). Kelly states that each of the serious outbreaks, including that of 1916, was preceded by seasons of excessive precipitation with excessive growth of volunteer grain during the summer and fall, followed by a mild winter; this in turn was followed by cool, dry, backward spring weather favorable for the insect but not for its natural enemies.

More recently less extensive outbreaks have occurred. Hyslop (5) reports that in 1922 one in Texas damaged grain from Bell County in central Texas to Bryan County, Okla. In 1926 an outbreak in Minnesota caused the loss of 15 million bushels of oats (7). Outbreaks each year from 1934 to 1939 threatened the small-grain crops in Oklahoma, according to Fenton and Fisher (2), but only in 1934 and 1939 did these develop into serious general infestations.

Studies of environmental conditions in relation to green bug outbreaks have been made by Wadley (9), Glenn (3), Fenton and Fisher (2), and others. All found that the green bug can reproduce normally at considerably lower temperatures than its principal enemies. Fenton and Fisher (2) studied population trends of both under natural conditions in the field and found that whereas the insect increased normally over a rather wide range of temperature, the parasites did not increase rapidly until daily minimum temperatures were above 50° F.

Few attempts have been made to control the insect with sprays or dusts, because such methods are difficult and impractical in the extensive plantings and with the low acre value of the grain crops. Whitehead and Fenton (12) suggest stamping out the early infestation centers through cooperative effort of growers by plowing under the crop or burning the areas. Spreading the parasitic wasp *Lysiphlebus testaceipes* (Cresson) forward to the advanced margins of infested areas has been attempted by Hunter (4). Webster and Phillips (11), however, found attempts to spread the parasite useless because of its wide natural occurrence and its ability to increase rapidly without assistance whenever weather conditions or abundance of host aphids are favorable to it.

Observations of varietal resistance among the small-grain crops have been limited. Webster and Phillips (11) mention wheat, oats, barley, and related grasses as food plants of the insect. Fenton and Fisher (2) reported that barley was preferred, followed by oats and then wheat. They noted some varietal differences in susceptibility to attack among oat varieties, Lee, Nortex, and Red Rustproof being more seriously damaged than Kanota, Coker Fulghum No. 4, or Columbia. They also observed that fall-sown barley following grain sorghum was more severely damaged than when following soybeans.

WEATHER CONDITIONS IN RELATION TO THE 1942 GREEN BUG OUTBREAK

As with many outbreaks of diseases or insects generally, weather conditions have an important bearing on the abundance of green bugs. Because of this, weather data for Texas for the period June 1941 to May 1942 are given in detail, with some comments on earlier conditions.

As previously mentioned, Fisher and Fenton (2) reported losses from the green bug in 1939. The presence of the insects was noted in north-central Texas the same year, although they did only minor damage. In 1940 and 1941 the green bug caused localized losses in north-central Texas, and as conditions were favorable it seems probable that populations of the aphid were built up over a large area during this period.

The average precipitation, number of rainy days, number of clear days, mean temperature, and humidity for the 11 months June 1941 to April 1942 and comparisons with long-time averages are given in table 1 for Abilene, Dallas, Temple, and Wichita Falls, Tex. In figure 1, monthly precipitation for the same period in comparison with the normal long-time averages is shown for the four stations.

Excessive precipitation over a large area in the summer of 1941 caused serious losses in quantity and quality of grain through delayed

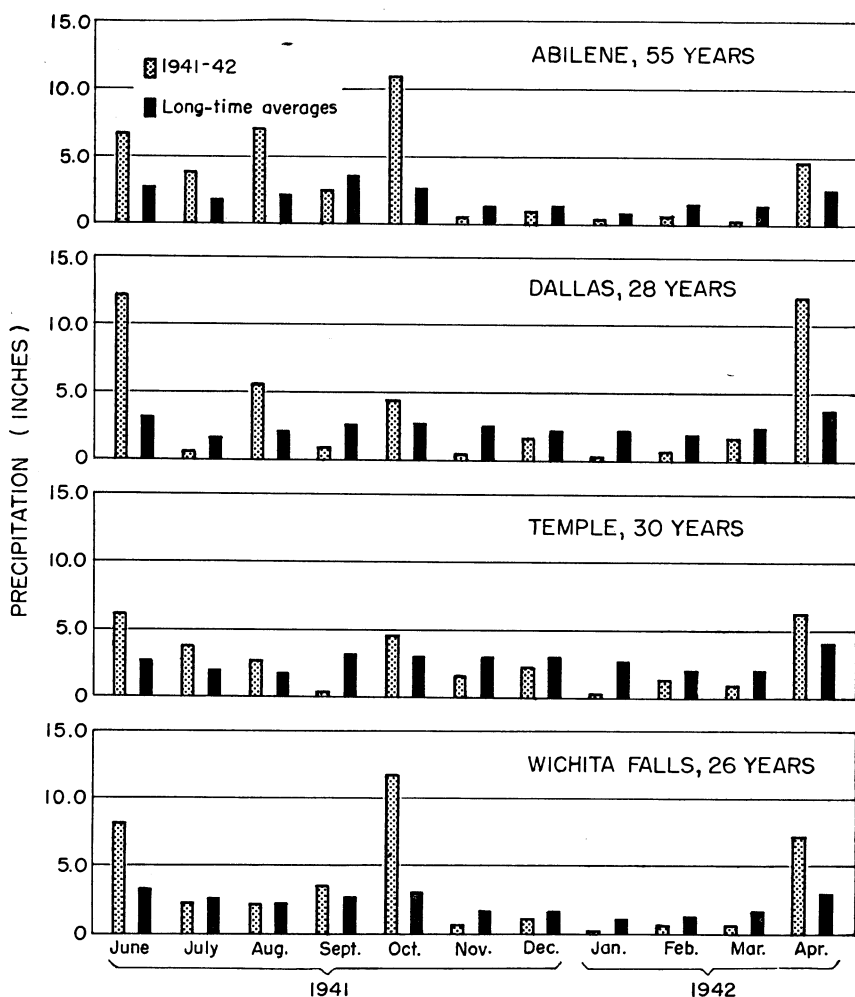


FIGURE 1.—Monthly precipitation compared with long-time averages at selected stations in Texas.

TABLE 1.—*Meteorological data for 1941-42 compared with long-time averages, 1885 to 1943, at selected stations in Texas*ABILENE, 55 YEARS, 1885-1939¹

Month	Mean temperature		Relative humidity		Total precipitation		Days with more than 0.01 inch precipitation		Clear days	
	1941-42	Average	1941-42	Average	1941-42	Average	1941-42	Average	1941-42	Average
	°F.	°F.	Percent	Percent	Inches	Inches	Number	Number	Number	Number
June.....	77.8	80.0	67	55	6.66	2.68	11	7	8	14
July.....	82.7	83.0	63	51	3.89	1.90	5	5	13	15
August.....	82.8	83.0	63	51	7.01	2.10	11	6	9	14
September.....	76.9	76.0	69	58	2.30	2.69	7	6	13	15
October.....	68.4	66.0	79	59	10.88	2.52	13	5	3	17
November.....	55.3	54.0	69	59	.50	1.36	4	5	12	14
December.....	49.2	46.0	67	60	.93	1.32	3	5	12	14
January.....	43.0	45.0	58	59	.08	.90	3	5	9	12
February.....	49.3	48.0	50	56	.54	1.06	5	4	8	10
March.....	56.6	56.0	41	50	.47	1.26	5	5	13	12
April.....	66.1	65.0	66	50	4.65	2.55	10	6	12	12

DALLAS, 28 YEARS, 1914-41¹

June.....	78.0	80.6	75	67	12.18	3.45	14	7	5	14
July.....	84.4	84.2	67	62	.76	1.81	7	5	16	16
August.....	84.4	84.1	63	60	5.54	2.29	12	6	12	16
September.....	79.9	78.1	67	61	1.22	2.61	3	5	14	16
October.....	71.3	68.0	78	63	4.57	2.93	12	6	1	16
November.....	55.2	55.9	68	66	.67	2.69	4	6	13	13
December.....	49.9	47.7	73	70	1.97	2.47	9	7	7	12
January.....	42.8	45.8	63	70	.47	2.49	4	8	14	12
February.....	48.4	49.5	64	67	.96	2.04	4	8	7	10
March.....	56.6	56.9	53	61	1.94	2.63	6	7	14	12
April.....	65.4	65.0	74	64	12.37	3.91	15	8	4	11

TEMPLE, 30-YEAR PERIOD²

June.....	79.1	80.8	81	71	6.25	2.81	14	6	1	13
July.....	82.5	83.7	78	68	3.80	2.06	5	5	2	14
August.....	83.6	83.9	79	67	2.70	1.99	7	5	6	14
September.....	80.9	78.4	79	71	.44	3.49	5	5	2	13
October.....	74.5	69.2	83	72	4.64	3.07	14	6	1	14
November.....	57.6	57.6	75	76	1.54	3.04	4	7	8	10
December.....	54.0	50.4	71	77	2.49	3.05	8	8	8	10
January.....	48.3	48.3	70	77	.37	2.54	3	9	11	11
February.....	51.9	52.2	72	75	1.48	2.21	6	8	4	9
March.....	60.0	59.0	71	69	.87	2.16	3	7	10	10
April.....	67.5	66.8	80	71	6.38	4.16	14	7	7	11

WICHITA FALLS, 26 YEARS, 1916-43³

June.....	76.9	81.5	.....	.....	8.22	3.49	12	.....	3	.....
July.....	83.5	85.0	.....	.....	2.42	2.60	3	.....	6	.....
August.....	84.0	85.6	.....	.....	2.29	2.35	8	.....	7	.....
September.....	77.0	78.4	.....	.....	3.53	2.71	4	.....	7	.....
October.....	68.4	68.0	.....	.....	11.77	3.01	12	.....	0	.....
November.....	53.9	54.5	.....	.....	.60	1.83	4	.....	15	.....
December.....	47.4	46.3	.....	.....	1.12	1.63	3	.....	8	.....
January.....	41.6	42.6	.....	.....	.13	1.09	3	.....	13	.....
February.....	46.3	48.0	.....	.....	.59	1.28	3	.....	11	.....
March.....	56.3	55.5	.....	.....	.50	1.63	5	.....	12	.....
April.....	66.8	66.1	.....	.....	7.35	2.98	11	.....	7	.....

¹ U. S. Weather Bureau data.² Data from Texas Substation No. 5, at Temple: Data on relative humidity and clear days for 28 and 29-year periods, respectively.³ No data for 1921 and 1922.

harvest, lodging, and shattering. This resulted in an enormous volunteer grain crop, which emerged early and continued growth through the summer and early fall. Under these conditions, abnormally large populations of the green bug lived through the summer and with favorable fall weather increased rapidly.

Weather conditions during November and December 1941 continued favorable, with subnormal precipitation and open weather and no great extremes in temperature. One severe cold snap from January 1 to 8, with a minimum of 8° F., killed many insects, but large numbers survived under a light snow cover. Weather during the rest of January

and throughout February and March was characterized by moderate to subnormal temperatures, strong winds, and cloudy skies, but with little precipitation. Temperatures were not sufficiently low to retard the green bug, but were too low for normal development of its parasites and predators. Under these conditions, small-grain crops grew slowly and the insect increased rapidly. Small-grain crops deteriorated rapidly during February and March. Spring-planted grain was destroyed as soon as it emerged. By March 15, temperatures were more favorable for parasitic insects and they increased rapidly. During the last week of March and the first week of April, the green bug in north-central Texas was brought under control by its parasitic and predaceous enemies and other factors. Winged forms appeared, and a general migration occurred. This carried the insect throughout most of the small-grain area of Oklahoma and into southern Kansas. Also, general rains occurred the first week in April, destroying many green bugs and reviving the small stand of surviving grain.

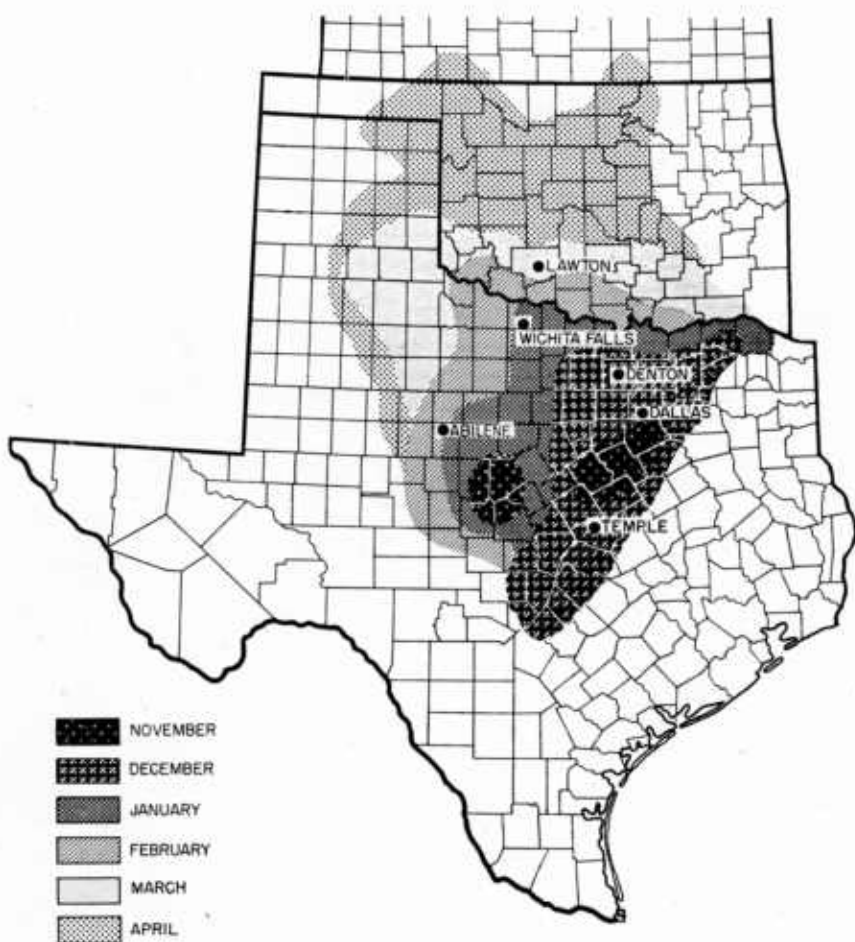


FIGURE 2.—Spread of green bug in Texas and Oklahoma shown by monthly periods, 1941-42.

The approximate spread of appreciable damage by the green bug is shown by monthly periods in figure 2. Reports obtained from each county indicate that damage was observed as early as November 1941 in two areas in central Texas, followed by initial damage over a rather wide area in December. The insect continued to migrate throughout the winter, the greatest spread occurring with the appearance of winged forms in March and April.

CROP LOSSES FROM THE 1942 ATTACK

Any attempt to estimate the loss from an insect outbreak is naturally subject to many errors and assumptions. A record of the best estimate of the loss caused by the widespread infestation of 1942, however, may be of value in indicating the serious damage this insect can do and serve to encourage further work on control measures. Estimates were obtained from the county agricultural agents in each county of Texas and Oklahoma of the damage to each of the small-grain crops. From these estimates figure 3 for wheat and figure 4 for oats and barley were prepared, showing the areas affected and the approximate damage

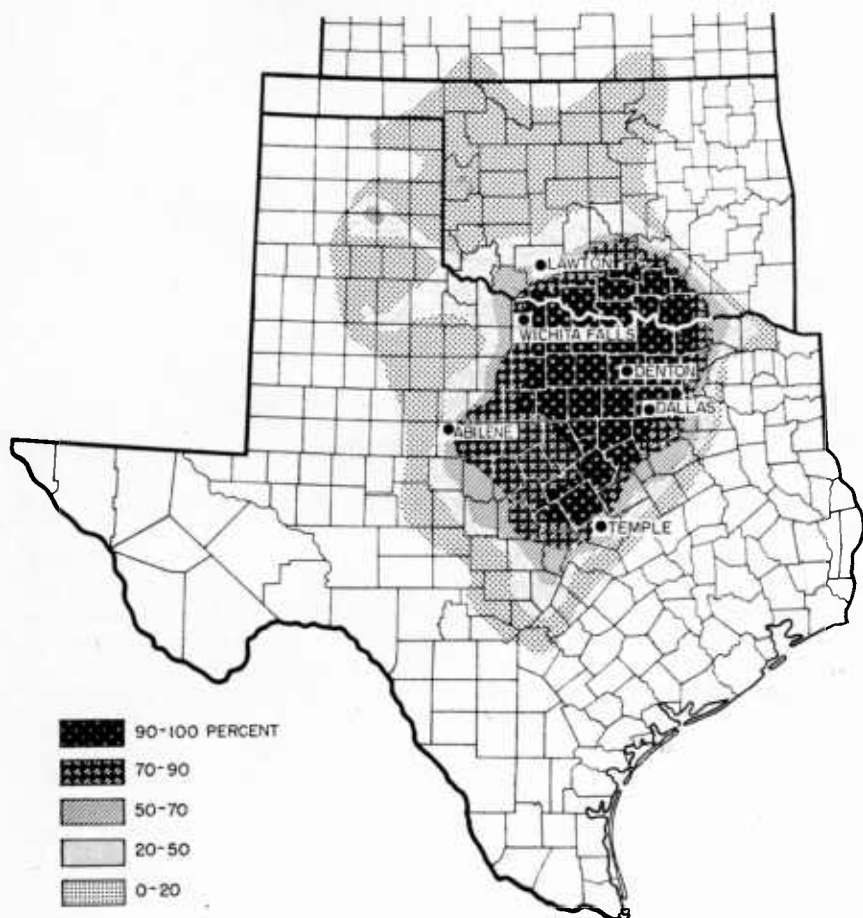


FIGURE 3.—Green bug damage to wheat in Texas and Oklahoma, 1942.

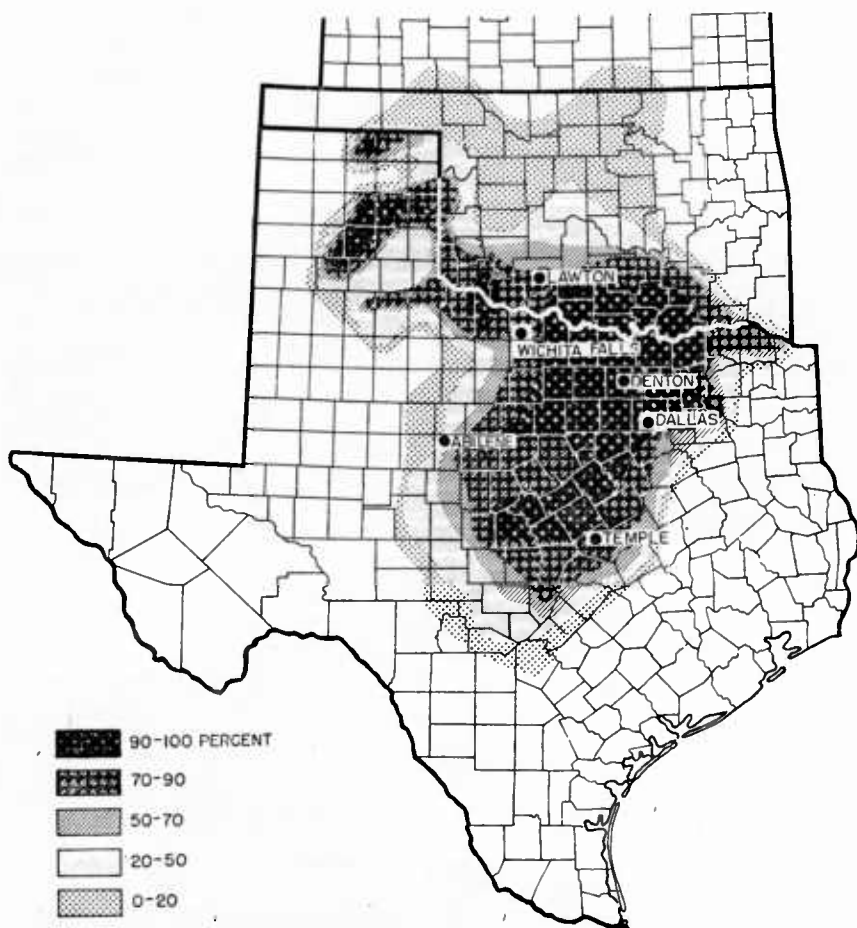


FIGURE 4.—Green bug damage to oats and barley in Texas and Oklahoma, 1942.

in each State. As will be observed the extent of damage was nearly the same for both oats and barley.

From figures 3 and 4 it is apparent that the green bug infestation covered most of the small-grain areas of Texas and Oklahoma and extended into southern Kansas. Wheat was damaged over a smaller area than oats and barley. A considerable part of the main wheat belt of Texas was damaged only slightly, and as a very favorable season followed, the total production for the State in 1942 was above average.

Losses were calculated with the help of C. A. Bonnen.³ The following method was used for Texas. The average annual harvested acreage for the State was determined for the period 1939-41, inclusive, rather than for longer periods, because of the rapid increase in oat and barley acreages in recent years. Reports of the 1942 planted acreage could not be used, as they are subject to normal abandonment and include that planted for pasture only. County acreages were then proportioned

³ Farm management specialist, Division of Farm and Ranch Economics, Texas Agricultural Experiment Station.

on the basis of the 1939 census, which is the latest record on a county basis. Normal yields for each county were taken from the crop yields by type-of-farming areas (1) used in arriving at wartime farm-production adjustments. These normal yields were based on information from a number of sources and were agreed upon by committees set up for each area to make recommendations of wartime adjustments. From these data the normal acreage and production for each county were computed and then the loss determined, using the estimate of damage supplied by the county agent in each county.

For Oklahoma the same method was used, except that no average yields by type-of-farming area were available; and the average yield per acre for the 1939 crop was used to compute the expected yield after acreages for each county were proportioned. The losses as estimated by these methods are presented in table 2. The percentage of the crop lost as given in table 2 is based on a normal crop represented by the 3-year average previously noted.

TABLE 2.—*Estimated losses of small grain in Texas and Oklahoma caused by the green bug in 1942*

State	Wheat			Oats			Barley			Total	
	Crop lost	Grain lost	Value (at 92 cents per bushel)	Crop lost	Grain lost	Value (at 54 cents per bushel)	Crop lost	Grain lost	Value (at 51 cents per bushel)	Grain lost	Value
	Per-cent	Bushels	Dollars	Per-cent	Bushels	Dollars	Per-cent	Bushels	Dollars	Bushels	Dollars
Texas.....	19	5,707,404	5,250,811	87	36,091,902	19,489,627	67	3,395,375	1,731,641	45,194,681	26,472,079
Oklahoma....	11	7,189,275	6,614,133	22	6,761,178	3,651,036	36	2,631,021	1,341,820	16,581,474	11,606,989
Total.....		12,896,679	11,864,944		42,853,080	23,140,663		6,026,396	3,073,461	61,776,155	38,079,068

The total estimated loss in the two States in 1942 thus exceeds the estimated 50-million-bushel loss in 1907 and may be considered the most serious outbreak of green bugs in history, even though it did not cover so large an area as that of 1907. In addition to the value of the grain, there must be included such additional losses as the value of winter pasture to stockmen, the loss of adapted seed stocks, and the cost of shipping in new seed for planting. The amount of these additional items would be hard to estimate, but certainly they are sufficiently heavy that they must be considered.

REACTION OF SMALL GRAINS TO GREEN BUG ATTACK

Breeding for resistance to insect attack is one of the more promising new fields of plant breeding. This work has recently been summarized by Snelling (8). One of the chief purposes of this bulletin is to report the outstanding differences in resistance to green bug attack observed in certain small-grain varieties and to record certain observed differences due to cultural practices.

INFLUENCE OF CULTURAL PRACTICES

Although it could hardly be expected that any method of seedbed preparation or any differences in type of fertility of soil or rate of seeding would serve as a control for the green bug, information on the effects of certain of these factors is of importance. County agents reported that land highly fertile, such as that on which cowpeas had been turned under or land fertilized with barnyard manure, showed

materially less damage than less fertile fields. The influence of previous crops on infestation by green bugs in wheat was also observed by Fenton and Fisher (2). At the United States Dry Land Field Station, Lawton, Okla., opportunity was afforded to observe differences in reaction of Turkey wheat where seedbeds had been prepared in several different ways. The results are shown in table 3.

TABLE 3.—*Green bug injury to Turkey wheat grown in field plots with different methods of seedbed preparation, Lawton, Okla., 1942*

Method of seedbed preparation	Leaves damaged	Method of seedbed preparation	Leaves damaged
	<i>Percent</i>		<i>Percent</i>
Basin-listed:		Early fall-plowed:	
Manured.....	34	With moldboard plow.....	40
Not manured.....	39	And sub oiled.....	47
Disked:		Deep.....	56
As needed to keep down weeds.....	54	Shallow.....	56
At seeding time.....	72	Late fall-plowed, shallow.....	50
As needed, plowed alternate years.....	45		

Observations in these experimental plots agree with those previously mentioned in that plants produced by the more desirable cultural practices were injured less than those on poorly prepared ground. While these practices offer no hope of complete control they may reduce the damage where infestation is moderate.

The influence of rate and date of seeding on green bug damage to oats was observed at Lawton. The data are presented in table 4.

TABLE 4.—*Leaf injury¹ by green bugs to Fulghum oats in a rate-and-date-of-seeding test, Lawton, Okla., 1942*

Rate per acre (pecks)	Injury to leaves on oats planted —					Average injury
	January 26	February 5	February 14	February 25	March 16	
	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>
4.....	60	56	67	70	76	65.8
6.....	57	52	49	46	66	54.0
8.....	55	44	45	53	60	51.4
10.....	46	44	46	52	54	48.4
Average.....	54.5	49	51.8	55.3	64	.....

¹ Notes on leaf injury were taken April 3, when plants in the January 26 planting were 67 days old and those of the March 16 planting 18 days old.

It is of value to note that plots having the lower rates of seeding were more severely injured in all instances. The greater injury on the late-seeded plots was to be expected, as the insect population increased during the period.

WHEAT VARIETIES

The green bug attack at Denton, Tex., started soon after fall emergence of grain. Infestation centers developed throughout the fields so that the severity of attack was not uniform in the experimental plantings or fields. For this reason dependable comparisons were difficult to make except where the strains were located in relatively small areas.

A group of 30 varieties and strains of winter wheat in the Uniform Rust Nursery of the United States Department of Agriculture at Denton, Tex., offered an opportunity to observe varietal differences

among wheats of rather wide sources and seeded in a small area uniformly infested. Plantings were made in single 10-foot rows, and the varieties are listed in planting order so that varietal differences may be better observed. Data on the reaction of these varieties to green bug attack are given in table 5. The estimates are of total damage to the

TABLE 5.—*Green bug damage to winter wheat varieties in the United States Department of Agriculture Uniform Rust Nursery grown at Denton, Tex., 1942*
[Superscript (in italic) indicates number of times recurrent variety was used as parent]

Variety or strain	C. I. ¹ No.	Estimated damage		Variety or strain	C. I. ¹ No.	Estimated damage	
		March 1	May 1			March 1	May 1
		<i>Percent</i>	<i>Percent</i>			<i>Percent</i>	<i>Percent</i>
Michigan Amber.....	5620	5	40	Hope × Hussar.....	11682	5	20
Trumbull.....	5657	5	40	Cheyenne × Tenmarq ..	11972	5	30
Denton.....	8265	(?)	10	Marquillo × Tenmarq....	12113	5	45
Fulcaster.....	6471	5	65	Kanred.....	5146	5	30
Mediterranean.....	3332	5	50	Tenmarq.....	6936	5	30
Minhardi.....	5149	5	50	Kharkof.....	1442	5	30
Trumbull × Fultz.....	12220	5	20	Malakof.....	4898	5	20
Wabash.....	11384	5	20	Comanche.....	11673	5	30
Trumbull × Fultz.....	12217	5	20	Pawnee.....	11669	10	60
Fultz sel. × Hungarian.....	11850	5	20	Kawvale × Tenmarq.....	11956	5	30
Do.....	12017	(?)	10	Do.....	11992	5	50
Wabash × Trumbull.....	12216	10	50	Marquillo × Oro.....	11979	(?)	10
Hussar.....	4843	5	50	Hope × Turkey.....	11964	(?)	10
Kawvale.....	8180	5	50	Hope × Cheyenne.....	11969	(?)	10
Minturki.....	6155	5	50	H-44 × Minturki ²	12022	5	40

¹ C. I. in this table and subsequently refers to accession number of the Division of Cereal Crops and Diseases.

² Trace.

variety as compared with normal growth and include leaf injury as well as some killing of plants.

The data in table 5 indicate some marked differences in resistance to green bug attack, although no variety showed sufficient resistance to survive severe attacks. Strains showing greatest resistance included Denton, Marquillo × Oro, Hope × Turkey, and Hope × Cheyenne. Fulcaster, Pawnee, and Kawvale were more susceptible than most other varieties. The resistance of Denton wheat and other Mediterranean strains was apparent in commercial fields in Denton County, Tex., as a few fields survived to produce a small crop when adjoining fields of Tenmarq and other varieties were killed. On many other farms, Denton and Mediterranean, as well as other varieties, were completely destroyed.

Another group of winter wheat strains, including domestic and foreign varieties being tested in preliminary trials, gave opportunity for observation on resistance and susceptibility. Data for these are given in table 6. The varieties are listed in planting order to show varietal differences on adjoining plots. Here also the estimates are of total damage as compared with normal growth and include leaf injury as well as killing of plants.

In this group of strains, Denton wheat again showed considerable resistance to green bug attack. Strains of Marquillo × Oro were the most resistant of any in the nursery, and this was observed in other plantings as will be noted later. Several Chinese wheat varieties showed little injury, which may have been due to their extremely early maturity. The foreign strains, such as P. I. Nos. 94454 and 94462 from the Union of Soviet Socialist Republics (Russia) and P. I. 109585 from Turkey, were considerably more resistant than Tenmarq.

TABLE 6.—*Green bug damage to miscellaneous winter wheat varieties grown in single 10-foot nursery rows, Denton, Tex., 1942*

Variety or strain	Origin of seed	Selection No.	P. I. ¹ No.	C. I. No.	Estimated damage	
					March 1	April 15
Denton (check).....				8265	<i>Percent</i>	<i>Percent</i>
Hope × Mediterranean sel.....		41-33-1-J19-4			5	20
Do.....		41-33-1-J13-4			5	50
Do.....		41-26-1-J1-4			5	40
Alabama Bluestem.....				6976	10	20
Thorne.....				11856	10	80
Leap selection.....				12185	30	80
Wabash.....				11384	10	90
Tenmarq (check).....				6936	10	40
Illinois No. 2.....				11537	5	40
Sanett.....				12224	20	90
Maretts Blue Straw 2-A.....					15	90
Maretts-Boggs Purple Straw No. 3.....					15	98
Kanred-Hard Federation × Tenmarq.....		37-34-54-1			5	30
Marquillo × Oro.....				11851	(2)	10
Do.....				11980	(2)	10
Do.....				11978	(2)	10
Oro × Ceres-Hope-Florence.....		Ks. 73-2			5	45
Denton (check).....				8265	(2)	15
Mentana.....	Italy.....		132856		95	100
Reasante.....	Armenia.....		94344		5	40
No. 22.....	do.....		94349		5	40
No. 88.....	Bulgaria.....		94407		10	90
No. 92.....	do.....		94411		10	85
No. 12-13.....	China.....		118726		5	20
Tenmarq (check).....				6936	15	70
Nanking No. 25.....	China.....		124270		5	15
Nanking No. 268.....	do.....		124322		5	20
Nanking No. 393.....	do.....		124340		5	20
No. 9446.....	U.S.S.R.....		92378		25	80
32 r/e 34.....	do.....		94454		5	10
37 r/e 34.....	do.....		94462		5	10
Ukrainka 0246.....			113942		5	10
No. 1037-30 (No. T-533) ³	Turkey.....		109583		5	30
No. 11-29 (No. T-535) ³	do.....		109585		5	10
Denton (check).....				8265	5	10
No. 1419-32 (No. T-539) ³	Turkey.....		109589		15	60
S. A. B. 129.....	China.....		117748		5	10
No. 124.....	do.....		118727		5	10
Akagawa Ako Ichigo.....	Japan.....		81793		10	60
No. 11388.....	U.S.S.R.....		94559		10	80
No. 22233.....	do.....		94574		25	80
No. 21-29 (No. T-534) ³	Turkey.....		109584		15	80
Kanred - Hard Federation 142 × Tenmarq.....		33-38-109			5	30
Tenmarq (check).....				6936	5	25

¹ P. I. refers to accession number of the Division of Plant Exploration and Introduction (formerly Foreign Plant Introduction).

² Trace.

³ Durum.

In several instances there were indications of segregation for moderate resistance among pure line segregates of wheat crosses. An example of this is given in table 7, where the reaction of a few selections from the cross Mediterranean, T. S. 5933-23 ⁴ - Hard Federation × Hope - Mediterranean selection 41-8-3 is shown in comparison with check plots of Denton and Tenmarq. These strains were grown in duplicate 4-row 10-foot nursery plots and were a part of a much larger group. Estimates of damage are made as described above.

The reactions of the segregates from this cross indicate that differences in resistance are inherited. Reactions in the two replications agree rather closely. Strain 124-40-130 was damaged only 27.5 percent, while strains 124-40-122 and 124-40-135 growing adjacent to it were damaged 96.5 and 72.5 percent, respectively. The high resistance of

⁴ Accession number, Texas Agricultural Experiment Station.

TABLE 7.—*Reactions to green bug attack among segregates of the cross Mediterranean, T. S. 5933-23-Hard Federation × Hope-Mediterranean selection 41-8-3 and of Denton and Tenmarq check plots grown in duplicate 4-row 10-foot nursery plots, Denton, Tex., 1942*

Strain or check variety	Estimated damage			Strain or check variety	Estimated damage		
	Repli- cation 1	Repli- cation 2	Average		Repli- cation 1	Repli- cation 2	Average
	Percent	Percent	Percent		Percent	Percent	Percent
Tenmarq (check).....	100	65	82.5	124-40-106.....	95	85	90.0
124-39-359-3.....	100	98	99.0	124-40-111.....	95	90	92.5
124-40-27.....	100	50	75.0	124-40-120.....	95	90	92.5
124-40-31.....	100	30	65.0	124-40-122.....	95	98	96.5
124-40-64.....	40	40	40.0	124-40-130.....	25	30	27.5
124-40-67.....	90	70	80.0	124-40-135.....	70	75	72.5
124-40-70.....	95	85	90.0	124-40-145.....	60	70	65.0
124-40-78.....	95	75	85.0	124-40-146.....	90	80	85.0
124-40-82.....	80	60	70.0	124-40-158.....	95	85	90.0
124-40-102.....	50	30	40.0	Tenmarq (check).....	100	75	87.5
Denton (check).....	20	30	25.0				

Denton wheat compared with many other strains is again indicated in the table and is shown in figure 5.

Replicated nursery tests of winter wheat arranged in a modified Latin square design, consisting of 97 varieties and 11 check plots in each replication, were grown at Denton and Chillicothe, Tex., in 1942. Al-

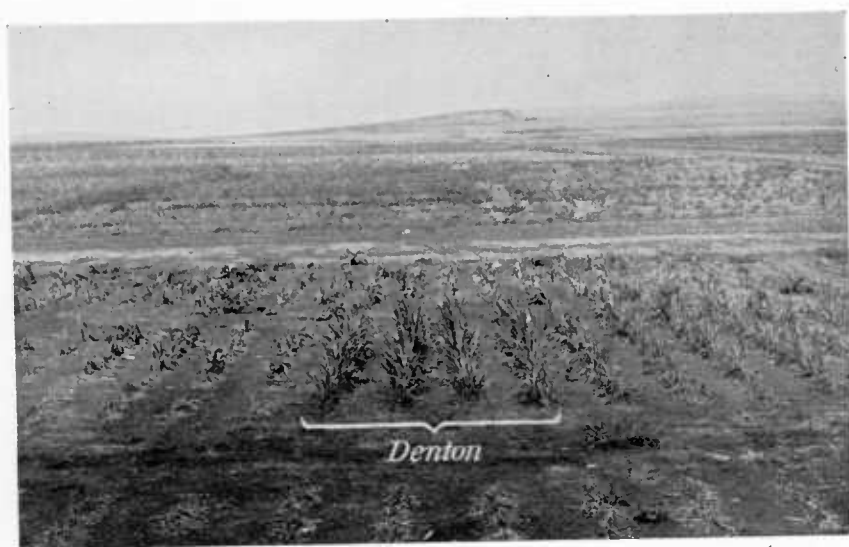


FIGURE 5.—The illustration shows the comparatively high resistance of Denton wheat to green bug attack, while strains from the cross Mediterranean, T. S. 5933-23-Hard Federation × Hope-Mediterranean selection 41-8-3, adjoining and in the foreground, were injured more seriously; Denton, Tex., 1942.

though the varieties in the tests were not identical, they were nearly so. At Denton the green bug damage was not uniform, owing to localized infestation centers, and notes on damage were taken on only one replication. At Chillicothe the infestation resulted largely from migrating green bugs, so all strains had equal opportunity to be damaged. Parasites and other factors brought the aphids under control before the crop was entirely destroyed, so that a small crop matured. Estimates of

TABLE 8.—*Green bug damage to varieties and strains of winter wheat grown in nursery plots, Denton and Chillicothe, Tex., 1942*[Superscript (in *italic*) indicates number of times recurrent variety was used as a parent]

Variety or strain	Selection No.	C. I. No.	Date headed	Estimated damaged at —	
				Chillicothe, average of 4 replications	Denton, 1 replication
Tenmarq × Blackhull.....	Wd. ¹ 36h29157		<i>May</i>	<i>Percent</i>	<i>Percent</i>
Marquillo × Oro.....	Ks. F. N. ² 790-1		4	11.2	
Do.....	Ks. F. N. ² 1433-16		12	15.0	5
Cheyenne × Blackhull.....		12112	5	21.2	20
Kanred-Hard Federation 254887 × Tenmarq.....	37-37-57		12	21.2	20
Blackhull.....			5	21.2	40
Kanred-Hard Federation × Minhardi-Minturki.....		6251	12	22.5	10
Marquillo × Oro.....	Ks. F. N. ² 787-1	11970	12	23.8	20
Kanred-Hard Federation 254887 × Tenmarq.....	37-35-3		4	23.8	5
Wichita.....			5	25.0	
Kanred-Hard Federation 254887 × Tenmarq.....	37-37-16	11952	4	25.0	20
Denton.....			8	25.0	30
Cheyenne × Early Blackhull.....		8265	14	27.5	5
Hope × Turkey.....		11999	5	27.5	10
Cheyenne × Early Blackhull.....		11964	15	28.8	10
Cheyenne × Tenmarq.....		12114	9	28.8	10
Kanred × Clarkan.....	74-37-87	12104	5	30.0	10
Kanred-Hard Federation 142 × Tenmarq.....	33-37-40		12	30.0	20
Kanred × Clarkan.....	74-37-29		4	30.0	30
Kanred-Hard Federation 142 × Tenmarq.....	33-38-88		13	32.5	
Marquillo × Oro.....		11979	5	32.5	30
Cheyenne × Early Blackhull.....		12000	12	33.8	10
Marquillo × Tenmarq.....		12113	5	33.8	15
Red Chief.....		12109	11	33.8	30
Martin × Tenmarq ³	50-37-121		9	35.0	90
Kanred-Hard Federation 142 × Tenmarq.....	33-37-67		12	35.0	
Early Blackhull.....			5	36.2	30
Martin × Tenmarq ³	50-37-92	8856	4	36.2	40
Kanred × Blackhull.....		11844	12	37.5	5
Kanred-Hard Federation 142 × Tenmarq.....	33-37-39		14	37.5	20
Kanred × Hope-Hard Federation			4	37.5	40
Kanred × Hard Federation 142 × Tenmarq.....	33-37-89	11975	9	40.0	10
Do.....	33-34-303		5	40.0	20
Do.....	33-35-26		5	40.0	30
Clarkan.....		8858	5	41.2	
Chiefkan.....		11754	12	41.2	30
Kanred-Hard Federation 142 × Tenmarq.....	33-38-27		12	42.5	10
Martin × Tenmarq ³	50-37-109		5	42.5	30
Do.....	50-33-63	11508	9	42.5	
Blackhull × Tenmarq.....		12102	5	42.5	70
Martin × Tenmarq ³	50-37-130		5	43.8	30
Tenmarq × Oro.....	70-38-44	12111	12	45.0	
Nebred.....		10094	12	45.0	20
Kanred-Hard Federation 142 × Tenmarq.....	33-34-271		14	45.0	20
Do.....	33-37-31		5	45.0	30
Tenmarq × P. 1066-Prelude.....	29-34-76		5	46.2	20
Blackhull × Cheyenne.....		12101	12	46.2	20
Cheyenne.....		8885	5	47.5	20
Tenmarq × P. 1066-1-Prelude.....	29-38-56		12	47.5	
Do.....	29-35-10		4	47.5	60
Kanred-Hard Federation 254887 × Tenmarq.....	37-35-2		12	48.8	40
Blackhull × Hard Federation.....	Wd. ¹ 1133-9		12	48.8	
Tenmarq × Oro.....	70-36-1		9	48.8	
Kanred-Hard Federation 142 × Tenmarq.....	33-35-27		12	50.0	
Hope × Cheyenne.....		11969	12	50.0	50
Tenmarq × P. 1066-1-Prelude.....	29-34-165		5	51.2	
Kanred-Hard Federation 142 × Tenmarq.....	33-35-31		5	52.5	10
Kanred-Hard Federation 25007 × Tenmarq.....	25-34-32		5	52.5	
			5	53.8	40

Least significant difference between the estimated damage of two varieties at Chillicothe at 0.05 point = 14.6 percent.

¹Wd. = Woodward, Okla.²Ks. F. N. = Kansas Fly Nursery.

TABLE 8.—*Green bug damage to varieties and strains of winter wheat grown in nursery plots, Denton and Chillicothe, Tex., 1942—Continued*

Variety or strain	Selection No.	C. I. No.	Date headed	Estimated damage at—	
				Chillicothe, average of 4 replications ^a	Denton, 1 replication
Tenmarq × P. 1066-1-Prelude.....	29-34-153		May 5	Percent 53.8	Percent 50
Vaughn Turkey (average of 24 checks).....	T. S. ^a 15133			55.4	
Kanred-Hard Federation 142 × Tenmarq.....	33-38-20		5	56.2	
Hope × Mediterranean.....	41-121		14	56.2	5
Tenmarq × P. 1066-1-Prelude.....	29-34-113		12	56.2	20
Martin × Tenmarq ²	50-37-85		12	56.2	50
Comanche.....		11673	11	57.5	10
Tenmarq × Oro.....	70-38-112		12	57.5	
Tenmarq × P. 1066-1-Prelude.....	29-36-44		12	57.5	20
Austin.....		12346	17	58.8	40
Cheyenne × Tenmarq.....		12103	12	58.8	40
Kanred-Hard Federation 25007 × Tenmarq.....	25-34-116	12110	12	58.8	80
Turkey.....		1558	8	60.0	30
Tenmarq.....		6936	12	60.0	40
Tenmarq × P. 1066-1-Prelude.....	29-34-141		12	60.0	
Kanred-Hard Federation 142 × Tenmarq.....	33-24-274		15	60.0	70
Vaughn Turkey.....	T. S. ³ 15133		14	61.2	
Kanred-Hard Federation 25007 × Tenmarq.....	25-34-44	12106	12	61.2	50
Kanred-Hard Federation 142 × Tenmarq.....	33-37-90	12115	4	63.8	20
Kanred-Hard Federation 25007 × Tenmarq.....	25-34-74		5	63.8	50
Kanred-Hard Federation 142 × Tenmarq.....	33-37-36		5	63.8	60
Tenmarq (average of 20 checks).....		6936		64.5	40
Kanred-Hard Federation 25007 × Tenmarq.....	25-34-135		12	65.0	40
Kawvale × Tenmarq.....		11992	12	66.0	20
Kanred.....		5146	15	66.2	10
Tenmarq × Oro.....	70-36-3		12	67.5	
Do.....	70-38-83		12	67.5	
Do.....	70-38-91		12	68.8	20
Do.....	70-37-38		12	68.8	70
Kanred-Hard Federation 254887 × Tenmarq.....	37-34-54	11974	12	70.0	10
Cheyenne × Tenmarq.....		11972	12	70.0	80
Kawvale × Tenmarq.....	35-34-117	11956	15	71.2	20
Kawvale.....		8180	13	71.2	60
Kanred-Hard Federation 142 × Tenmarq.....	33-37-87		8	72.5	
Kharkof.....		1442	12	73.8	30
Tenmarq × Oro.....	70-38-125		12	75.0	40
Do.....	70-38-34		12	77.5	
Kawvale × Tenmarq.....		11950	12	78.8	90
Pawnee.....		11669	15	82.2	20
Tenmarq × Oro.....	70-38-147		15	82.5	60
Kanred-Hard Federation 142 × Tenmarq.....	33-34-111		12	87.5	30

^a T. S. = Texas station.

damage at Chillicothe are averages of four replications, detailed data for each of which are on file. The analysis of variance test indicates that at the 0.05 point the least significant difference between the means of two varieties is 14.6 percent. Data on damage observed in the tests are presented in table 8 in order of increasing damage to varieties rather than in planting order, as was done in previous tables. Estimated damage is total injury, as in previous tables.⁵

Some rather marked differences in green bug damage were observed in the above tests. In general, the observations on resistance at the two stations are in agreement, as they also are with the data previously presented in tables 5 and 6. Among the most susceptible varieties may be mentioned the Kawvale × Tenmarq strains, including Pawnee.

⁵ Data presented through the courtesy of J. R. Quinby, Superintendent, Texas Substation No. 12, Chillicothe, Tex.

Highest resistance to attack was shown by the Marquillo \times Oro strains, Denton, Hope \times Turkey (C. I. 11964), and the Blackhull wheat group. Several hybrid strains involving Blackhull or Early Blackhull also showed high resistance, indicating that these hybrid strains may have inherited the resistance of the Blackhull group. In commercial plantings in the Chillicothe area, Early Blackhull was damaged much less than other varieties. Whether earliness directly influenced resistance has not been determined. The data in table 8 indicate no very definite relationship between earliness and resistance, but there is a slight tendency for the later maturing lines to show heavier damage. Selections from the cross Kanred-Hard Federation 254887 \times Tenmarq were among the more resistant strains, while selections from two similar crosses, Kanred-Hard Federation 25007 \times Tenmarq and Kanred-Hard Federation 142 \times Tenmarq, were nearly all very susceptible.

Several varieties of winter wheat were grown in replicated field plots at Chillicothe and Denton, Tex., and Lawton, Okla. All plantings at Denton were killed, but at both Chillicothe and Lawton partial survival permitted good observations on reaction to attack. The varieties included in the tests were the same for the most part. Data on reactions of these varieties are given in table 9. Estimates of damage are total injury and include injured leaves as well as killing, as in other tables.

The results were similar to those in the nursery tests. At Lawton the range in damage was rather small, but in general the more resistant strains were the same as at Chillicothe, where the damage was severe.

TABLE 9.—*Green bug damage to winter wheat varieties grown in field plot tests, Chillicothe, Tex., and Lawton, Okla., 1942*

[Superscript (in *italic*) indicates number of times recurrent variety was used as a parent]

Variety or strain	C. I. No.	T.S. No.	Chillicothe, Tex.			Lawton, Okla.		
			Estimated damage		Yield of grain	Estimated damage		Yield of grain
			Average, 4 replications	Rank		Average, 3 replications	Rank	
			<i>Percent</i>		<i>Bushels</i>	<i>Percent</i>		<i>Bushels</i>
Wichita.....	11952	26984	36.3	1	12.9	27.3	6	26.5
Red Chief.....	12109		45.0	2	11.1	26.7	5	13.5
Early Blackhull.....	8856	15838	53.8	3	9.3	23.3	2	24.2
Denton.....	8265	9236	58.8	4	7.9			
Kanred-Hard Federation 142 \times Tenmarq.....	12105		62.5	5	7.3			
Comanche.....	11673	24951	63.8	6	7.8	34.0	16	20.9
Chiefkan.....	11754	23276	65.0	7	6.9	22.0	1	11.6
Blackhull.....	6251	7172	66.3	8	7.1	29.3	10	18.0
Martin \times Tenmarq ¹	11805		72.5	9	5.2			
Kanred-Hard Federation 25007 \times Tenmarq.....	12106		76.3	10	4.6			
Tenmarq.....	6936	12578	77.5	11	4.3	27.7	7	16.9
Kawvale \times Tenmarq.....	11956		78.8	12	4.2	29.0	9	24.8
Turkey.....	1558		81.3	13	3.5	43.3	21	11.0
Cheyenne.....	8885	18566	83.8	14	3.2	33.0	15	14.9
Pawnee.....	11669		83.8	14	2.9	30.3	13	15.4
Mediterranean.....	11587		86.3	16	2.7			
Kanred.....	5146	11736	86.4	17	2.5	31.7	14	19.5
Kharkov.....	1442	16830	87.5	18	2.3	38.3	18	12.9
Kawvale \times Tenmarq.....	11750		92.5	19	1.7	34.7	17	20.5
Turkey \times Kawvale, La. 35-93.....						25.7	3	12.3
Clarkan.....	8858	20400				25.7	3	15.1
Harvest Queen.....	6199					28.7	8	11.4
Penquite.....	11745	23243				29.7	11	13.8
Kawvale.....	8180	12577				30.0	12	20.5
Sibley 62.....	11523	20481				39.0	19	18.9

In both tests Pawnee and other Kawvale \times Tenmarq strains were among those more seriously damaged. The relative damage was reflected in final yields of grain.

BARLEY VARIETIES

As noted previously, barley is one of the favored host plants of the green bug in this region. Opportunity to observe the reaction of a very large number of varieties from world-wide sources was afforded by the extensive plantings at Denton, Tex., and Lawton, Okla. The high resistance and survival of some strains under heavy infestation give encouragement to the project of breeding adapted resistant varieties.

For several years, a study of winter hardiness of barley varieties has been conducted by the Division of Cereal Crops and Diseases, Bureau of Plant Industry, Soils, and Agricultural Engineering. Usually 40 varieties are included, these being grown at all experimental stations in the winter barley area. This group of varieties was grown at both Denton, Tex., and Lawton, Okla., where notes on reaction to attack were recorded. The data are given in table 10. Estimates of damage are the average of two replications, the varieties being arranged in order of increasing injury as observed at Denton. Estimates given are total injury to the plot compared with normal growth and include leaf injury as well as killing of plants. Observations at Lawton are expressed both as percentage of injury to the variety and as percentage of the nearest Tennessee Winter check plot.

TABLE 10.—Green bug damage to winter barley varieties in the United States Department of Agriculture Uniform Winter-Hardiness Nursery, grown at Denton, Tex., and Lawton, Okla., 1942

Variety	C. I. No.	Estimated damage ¹ at Denton, Tex.	Estimated damage, ¹ Lawton, Okla.		
			Named variety	Percentage of nearest Tennessee Winter (check)	Rank
		Percent	Percent	Percent	
Nu Er Ta.....	741	7.5	34.0	78.2	3
Esaw.....	4690	7.5	38.5	81.0	5
Sunrise.....	6272	12.5	29.5	67.8	1
Smooth Awn 86.....	6268	20.0	33.5	70.5	2
Wong.....	6728	25.0	33.5	79.8	4
Iredell.....	6571	87.5	43.0	90.5	13
Davidson.....	6373	90.0	38.5	88.5	11
Randolph.....	6372	90.0	39.0	89.7	12
North Carolina 11.....	6564	92.5	39.5	90.8	14
Tennessee Winter (checks).....	6034	94.3	45.9	100.0	25
Ward.....	6007	95.0	42.0	81.6	7
Reno.....	6561	95.0	43.5	84.5	8
Clemson Hooded.....	7042	95.0	45.5	95.8	20
Jackson 1.....	7045	95.0	46.5	97.9	24
Marnobarb.....	6120	95.0	49.0	103.1	29
Texan.....	6499	95.0	49.5	104.2	31
Poland.....	6280	97.5	47.5	92.2	16
Wisconsin Winter.....	2159	97.5	45.5	92.9	17
Tennessee Beardless 6.....	2746	97.5	45.5	95.8	20
Missouri Early Beardless.....	6051	97.5	46.0	96.8	22
Tenkow.....	646	97.5	44.5	102.3	28
Manchuria.....	245	97.5	45.0	103.5	30
Wintex.....	6127	97.5	46.0	105.8	32
Santiam.....	6367	99.0	44.0	101.2	27
Ohio 1.....	7072	100.0	34.0	81.0	5
Mercer.....	7071	100.0	35.5	84.5	8
Polders.....	3213	100.0	38.0	87.4	10
Jackson.....	6569	100.0	43.5	91.6	15
Purdue 28154A3-1-1-6.....	7067	100.0	39.0	92.9	17
Kentucky 1.....	6050	100.0	46.0	93.9	19
Purdue 21.....	4581	100.0	47.5	96.9	23
Purdue 1101.....	4582	100.0	49.0	100.0	25
Trebi.....	936	100.0	46.0	107.0	33

¹ Average of 2 replications.

At Denton, Tex., where the insect population was very great, most varieties were soon killed. The resistance of Smooth Awn 86, Esaw, Sunrise, Wong, and Nu Er Ta was outstanding. These varieties survived and produced a good crop when all strains surrounding them were killed. At Lawton, Okla., the attack was of shorter duration, so that damage was not so severe, but the same varieties showed high



FIGURE 6.—Survival of barley varieties following attack of the green bug at Denton, Tex., 1942. in 2-row 12-foot plots: *A*, Iredell; *B*, Tennessee Winter; *C*, Clemson Hooded; *D*, Esaw; *E*, Sunrise. In the next block in the background may be seen Nu Er Ta and Wong, which survived the attack.



FIGURE 7.—Smooth Awn 86 barley survived when all surrounding strains were killed by the green bugs; Denton, Tex., 1942.

resistance. The resistant varieties Esaw and Sunrise are selections from a natural cross of Nakano Wase, a Japanese variety. Esaw is also one of the parents of Smooth Awn 86. The high resistance of these strains is shown in figures 6 and 7.

Another group of foreign and domestic barley varieties were grown in single 2-row 12-foot plots at Denton in comparison with check plots of Wintex and Texan. The data from this test are recorded in table 11, the varieties being listed in order of severity of damage.

TABLE 11.—*Green bug damage to miscellaneous winter barley varieties grown in single 2-row 12-foot nursery plots, Denton, Tex., 1942*

Variety	C. I. No.	Estimated damage	Rank	Origin or source
		Percent		
Peru.....	707	5	1	North Africa.
Kunshan.....	1065	5	1	China.
Malwet.....	2459	5	1	Do.
Omugi.....	5144	5	1	Chosen.
Sonbaku.....	5151	10	5	Do.
Nipa.....	2471	20	6	China.
Hoodless Beardless.....	1803	35	7	Saskatchewan.
Pidor.....	901	80	8	Tennessee Winter × Hankow.
Kinroku.....	5265	85	9	Chosen.
Arabel.....	896	85	9	Tennessee Winter × Black Arabian.
Temple.....	1046	90	11	China.
Unnamed.....	2420	90	11	California.
Texan (check).....	6499	90	11	Selection from Composite Cross, C. I. 5530.
Unnamed.....	3883	90	11	Kashmir.
Dohadak.....	5187	90	11	Chosen.
Nipa.....	2471	90	11	China.
Maretts Awnless 1.....	7073	95	17	South Carolina.
Wintex (check).....	6127	100	18	Selection from farmer's field in Texas.
Telli.....	194	100	18	North Africa.
Argentine.....	223	100	18	Argentina.
Santizo.....	1049	100	18	China.
Michigan Winter.....	7032	100	18	Oklahoma.
Orkoe.....	2465	100	18	China.
Maynang.....	2429	100	18	Do.
Maretts Hooded 4.....	7074	100	18	South Carolina.
Zehra.....	5189	100	18	Chosen.

Extreme differences in susceptibility to green bug attack were observed in this group of varieties. Omugi was damaged only 5 percent, maturing a good crop while the adjoining plot of the Unnamed strain (C. I. 3883) from Kashmir was damaged 90 percent. The varieties Peru, Kunshan, Malwet, and Omugi all showed high resistance, being damaged only 5 percent each, while the standard varieties Wintex, Texan, and Michigan Winter were almost completely destroyed. The resistance and susceptibility of a number of varieties included in this test are shown in figure 8.

At Lawton, Okla., a group of 91 varieties of winter barley was grown from fall seeding in single 5-row 10-foot nursery plots. Check plots of Michigan Winter were spaced at intervals of 10 plots. The test included most of the commercial winter barleys grown in the United States, as well as many winter types from widely separated parts of the world. As mentioned previously, the green bug infestation at Lawton was largely the result of migration, and the insects were brought under control by parasites and other factors before complete killing occurred. The first notes on injury were taken April 3 to 7 at each of four places in each plot. About 10 days later, April 17, a second note was taken to indicate the percentage of the leaves infested. The

final note, taken April 30, was an estimate of the total injury to the entire plot, including leaf injury and killing of plants. The first two observations are recorded as percentages for the named variety, while the last is in proportion to the nearest Michigan Winter check plot, in order to overcome any possible variation due to location. Data for the 91 strains are presented in table 12 and are arranged in order of increasing injury to the variety.

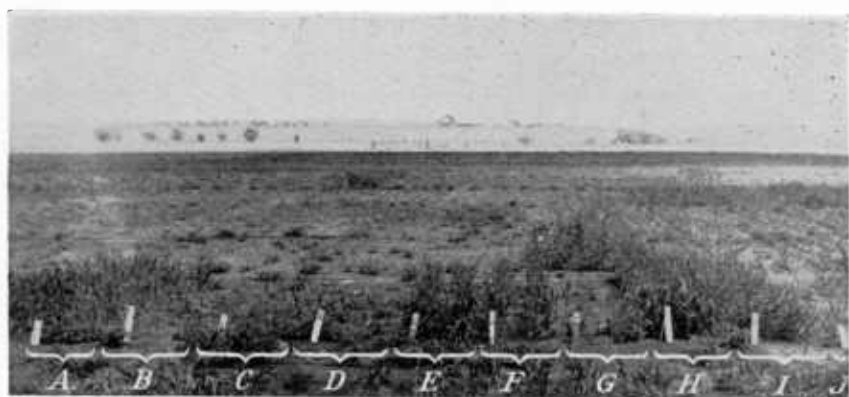


FIGURE 8.—Reaction of barley varieties to green bug attack, Denton, Tex., 1942: A, Hooded Beardless, 35 percent damaged; B, Unnamed strain (C. I. 2420), 90 percent; C, Texan, 90 percent; D, Maynang, 100 percent; E, Malwet, 5 percent; F, Nipa, 20 percent; G, Unnamed strain (C. I. 3883), 90 percent; H, Omugi, 5 percent; I, Sonbaku, 10 percent; and J, Dohadak, 90 percent.

The data indicate that some varieties are rather resistant to green bug attack and that the reaction at Lawton, Okla., was similar to that at Denton, Tex., where infestation was even greater. Total damage to the plots ranged from 15.6 percent (based on percentage of the nearest Michigan Winter check plot) for Rufino to 135.8 percent for Composite Cross selection (Okla. 39-5267). The varieties Omugi, Esaw, and Dobaku were highly resistant at both stations, while Wintex, Texan, and all Tennessee Winter strains, including Ward, Reno, and Michigan Winter, were seriously damaged or completely killed.

Differences in the nature of reaction to attack also are indicated. For example, Rufino was damaged only 15.6 percent in spite of 50 percent infestation of the leaves and 34 percent of the leaves showing injury at the early inspections, whereas Dorshu was damaged 25 percent, with only 12 percent of the leaves infested and 23 percent of the leaves injured. Also, White Gatami (Oklahoma 39-8027), with 93 percent of the leaves infested, was damaged about 29 percent, while Kipo, with only 16 percent of the leaves infested, was damaged almost 35 percent.

For the purpose of studying resistance to chinch bug attack, a group of 99 varieties and strains, some winter and some spring types, were spring-seeded in 5-row 10-foot nursery plots in a triple-lattice design at Lawton. This test offered a valuable opportunity to study the reaction of these varieties to green bug attack. Detailed notes were taken for each replication and are on file at Lawton, and only the averages

TABLE 12.—Green bug damage to fall-sown barley varieties grown in single 5-row 10-foot nursery plots at Lawton, Okla., 1942

Variety	C. I. No.	Origin or source	Leaves injured April 7 ¹	Leaves infested April 17 ²	Total injury to plot April 30 ³
			<i>Percent</i>	<i>Percent</i>	<i>Percent</i>
Rufino.....	2475	China.....	34	50	15.6
Dorshu.....	5154	Chosen.....	23	12	25.0
Shumaki.....	5222	do.....	34	25	25.3
Seibaku.....	5229	do.....	25	32	26.3
Dobaku.....	5238	do.....	16	32	26.3
White Gatami.....	920	do.....	18	93	29.4
Unnamed.....	5087	China.....	34	80	29.4
Shonan.....	5255	Chosen.....	24	21	32.3
Unnamed.....	5092	China.....	41	57	32.3
Kipo.....	5242	Chosen.....	32	16	34.9
Omugi.....	5144	do.....	34	26	38.5
Rangubori.....	5239	do.....	30	35	39.0
Mignon.....	999	U. S. S. R.....	32	60	42.9
Borido.....	5236	Chosen.....	40	35	42.9
Ghest.....	979	U. S. S. R.....	41	77	42.9
Fesun.....	2463	China.....	38	48	44.1
Esaw.....	4690	Nakano Wase × Unknown	28	82	45.5
Niver.....	737	China.....	37	62	45.5
Warabe.....	5205	Chosen.....	36	45	45.5
Lopat.....	2477	China.....	32	65	46.2
Orkoe.....	2465	do.....	31	87	46.9
Pontius.....	731	do.....	48	62	50.0
Tenkow.....	646	Tennessee Winter × Hankow.....	46	90	53.3
Kinroku.....	5265	Chosen.....	31	73	53.3
Amarillo.....	1073	China.....	20	43	53.6
Nangmay.....	2426	do.....	37	70	53.6
Ruble.....	870	Venezuela.....	36	82	54.1
Arlington Awnless.....	702	Tennessee Winter × Black Arabian.....	31	55	55.6
Peru.....	707	North Africa.....	44	72	56.3
Composite Cross selection (Oklahoma 39-5255).....		Selection from Composite Cross, C. I. 5530.....	59	82	56.8
Composite Cross selection (Oklahoma 39-5249).....		do.....	44	70	57.2
Black Smyrna.....	191	do.....	42	85	57.2
Bakson.....	5244	Chosen.....	38	75	57.2
Gumshu.....	5217	do.....	49	55	58.0
Composite Cross selection (Oklahoma 39-5250).....		Selection from Composite Cross, C. I. 5530.....	46	38	59.7
Iredell.....	6571	North Carolina selection from Tennessee Beardless 6.....	48	34	60.6
Santol.....	2468	China.....	35	85	60.6
Banando.....	5210	Chosen.....	39	86	61.7
Lochink.....	2460	China.....	42	88	62.5
Nu Er Ta.....	741	do.....	55	92	63.5
Horsford.....	2324	do.....	55	98	64.5
Ton Pori.....	5150	Chosen.....	45	70	65.8
Unnamed.....	5088	China.....	50	93	69.0
Han River.....	206	do.....	54	80	69.4
Argentine.....	223	Argentina.....	52	87	69.4
Coast.....	626	do.....	56	93	71.4
Telli.....	194	North Africa.....	55	83	71.4
Abyssinian.....	1231	Abyssinia.....	44	82	71.5
Composite Cross selection (Oklahoma 35h9-9).....		Selection from Composite Cross, C. I. 5461.....	46	97	71.5
Sonbaku.....	5151	Chosen.....	54	97	71.5
Black Smyrna.....	191	Asia Minor.....	46	85	71.5
Composite Cross selection (Oklahoma 35h10-3).....		Selection from Composite Cross, C. I. 5461.....	40	97	71.5
Kotsu.....	5161	Chosen.....	38	96	71.5
Composite Cross selection (Oklahoma 39-5242).....		Selection from Composite Cross, C. I. 5530.....	38	72	72.2
Wisconsin Winter.....	519	Europe.....	60	74	73.2
Missouri Early Beardless.....	6051	Selection from Missouri farmer's field.....	44	37	74.1
Davidson.....	6373	Selection from Composite Cross, C. I. 5461.....	47	85	76.9
Hooded 10.....	6563	Selection from Tennessee Beardless 6.....	59	50	76.9
Bodzu.....	753	Japan.....	35	73	76.9
Lico.....		Lion × Coast.....	50	83	78.1
Oni.....	5188	Chosen.....	45	80	80.6
North Carolina 11.....	6564	Selection from Composite Cross, C. I. 5461.....	40	84	82.0
Tongukotsu.....	5211	Chosen.....	34	61	83.3

¹Percentage of leaves injured, determined from inspection of 25 plants at 4 locations in each plot.²Percentage of leaves infested, determined from inspection of 100 plants in center row of each plot.³Estimate of injury to entire plot, converted to percentage of nearest check plot.

TABLE 12.—*Green bug damage to fall-sown barley varieties grown in single 5-row 10-foot nursery plots at Lawton, Okla., 1942—Continued*

Variety	C. I. No.	Origin or source	Leaves injured April 7 ¹	Leaves infested April 17 ²	Total injury to plot April 30 ³
Composite Cross selection..	6502	Selection from Composite Cross, C. I. 5530.	Percent 40	Percent 96	Percent 83.3
Moldavia.....	392	Rumania.....	26	77	85.7
Composite Cross selection..	6500	Selection from Composite Cross, C. I. 5530.	44	92	85.7
Odessa.....	182	U. S. S. R.....	48	87	85.7
Keiroku.....	5240	Chosen.....	48	82	85.7
Dohadak.....	5187	do.....	60	98	85.7
Rice.....	742	China.....	55	78	86.2
Poree.....	2428	Japan.....	63	98	89.7
Tennessee Winter.....	3546	Selection from Tennessee Winter.....	54	83	89.7
Composite Cross selection (Oklahoma 39-5254).....		Selection from Composite Cross, C. I. 5530.	49	94	92.0
Santaku.....	5139	Chosen.....	44	71	95.2
Reno.....	6561	Farm in Kansas.....	40	97	100.0
Ward.....	6007	Farm in Oklahoma.....	44	92	100.0
Luth.....	908	Selection from farmer's field in Minnesota.	45	98	100.0
Unnamed.....	2420	California.....	47	80	100.0
Trebi.....	936	Asiatic Turkey.....	50	97	100.0
Composite Cross selection (36Ab6308).....		Selection from Composite Cross, C. I. 5461.	46	89	100.0
Composite Cross selection (Oklahoma 39-5245).....		Selection from Composite Cross, C. I. 5530.	52	99	100.0
Michigan Winter (check)....	7032	Oklahoma.....	56	90	100.0
Composite Cross selection (Oklahoma 35h10-2).....		Selection from Composite Cross, C. I. 5461.	37	92	100.0
Composite Cross selection (Oklahoma 39-5268).....		Selection from Composite Cross, C. I. 5530.	54	68	102.9
Texan.....	6499	do.....	68	94	108.1
Tennessee Winter X Smooth Awn.....	6565	Tennessee Winter X Smooth Awn.....	76	95	109.6
Santiam.....	6367	Selection from Composite Cross, C. I. 5530.	43	95	114.3
Wintex.....	6127	Selection from farmer's field in Texas.....	59	100	121.6
Composite Cross selection (Oklahoma 35h9-12).....		Selection from Composite Cross, C. I. 5461.	67	100	128.6
Unnamed.....	3883	Kashmir.....	38	98	133.3
Composite Cross selection (Oklahoma 39-5267).....		Selection from Composite Cross, C. I. 5530.	70	100	135.8

¹ Percentage of leaves injured, determined from inspection of 25 plants at 4 locations in each plot.² Percentage of leaves infested, determined from inspection of 100 plants in center row of each plot.³ Estimate of injury to entire plot, converted to percentage of nearest check plot.

are presented here. As in the fall-sown test, three notes were taken: (1) Percentage of leaves injured on April 7; (2) estimated injury to the entire plot on April 25, which included leaves injured and plants killed; and (3) a final note on April 30, with counts of the percentage of plants killed. These notes were slightly different from those on the fall-sown tests, where the second note was one of the percentage of leaves infested with green bugs and the final note one of the general injury to the plot.

The average for each of the three notes is given in table 13, with the varieties arranged in order of increasing injury, as indicated by the total injury note on April 25. An analysis of variance of the data on leaf injury from the first note taken shows that the standard error of an adjusted mean difference between varieties located together in a block is 5.86 percent and for those not together in a block 5.96 percent. The adjustments are not large. For unadjusted means, given in table 13, a difference of 14 percent or more would be significant.

Many varieties included in the fall-sown test reported in table 12 were included also in the spring-planted group reported in table 13. In general their reaction was the same. Among the more resistant

TABLE 13.—*Green bug injury to winter barley varieties spring-seeded in 5-row 10-foot nursery plots in a triple-lattice design, Lawton, Okla., 1942*

Variety	C. I. No.	Origin or source	Leaves injured April 7 ¹	Total injury April 25 ²	Plants killed April 30 ³
			<i>Percent</i>	<i>Percent</i>	<i>Percent</i>
Mignon.....	999	U. S. S. R.....	24.7	10.0	0
Dobaku.....	5238	Chosen.....	23.7	13.3	0
Omugi.....	5144	do.....	24.3	13.3	.6
Felix.....	1457	Mesopotamia.....	27.7	13.3	3.3
Ruffno.....	2475	China.....	26.3	16.7	2.0
Kumfide.....	730	do.....	26.7	20.0	9.9
Hoodless Beardless.....	1803	Saskatchewan, Canada.....	33.3	26.7	13.1
Gatami (Oklahoma 39-8004).			30.0	26.7	8.5
Nunca.....	2473	China.....	32.2	30.0	7.3
Turkestan.....	712	Turkestan.....	35.7	30.0	12.8
Kinroku.....	5265	Chosen.....	36.0	30.0	3.8
Pannier.....	1330	Kashgar.....	40.0	30.0	15.7
Uncharne.....	2474	China.....	35.7	36.7	8.0
Good Delta X Flynn (40Ab578).		Good Delta X Fl. nn.....	37.0	36.7	19.6
Quinn.....	1024	Australia.....	38.3	36.7	17.3
Horsford.....	2324	China.....	40.3	36.7	4.5
Wanfat.....	2461	do.....	36.7	40.0	12.5
Flynn X Stavropol (H. C. 37-3046).		Flynn X Stavropol.....	37.7	43.3	19.0
Niver.....	737	China.....	38.3	43.3	18.1
Lochink.....	2460	do.....	41.0	46.7	22.7
White Gatami.....	920	do.....	42.3	46.7	3.3
Olonets.....	198	U. S. S. R.....	28.7	46.7	34.0
Stavropol (H. C. 249).....	5913	do.....	43.7	46.7	36.0
Rorido.....	5236	Chosen.....	44.0	46.7	12.8
Ton Pori.....	5150	do.....	45.0	46.7	4.9
Venus.....	736	China.....	38.7	50.0	13.9
Esaw.....	4690	Nakano Wase X Unknown.....	42.3	50.0	10.4
Beecher.....	6566	Atlas X Vaughn.....	44.0	50.0	56.5
Malwet.....	2459	China.....	41.3	53.3	22.2
Composite Cross selection (Oklahoma 35h9-5).		Selection from Composite Cross, C. I. 5461.....	42.0	53.3	67.8
Vaughn.....	1367	Club Mariout X Licn.....	42.0	53.3	25.9
Nu Er Ta.....	741	China.....	43.3	53.3	24.5
Davidson.....	6373	Selection from Composite Cross, C. I. 5461.....	43.7	53.3	48.1
Vaughn X Stavropol (H. C. 394).		Vaughn X Stavropol.....	44.0	53.3	24.2
Black Smyrna.....	191	Asia Minor.....	45.7	53.3	32.3
Leh.....	700	India.....	47.3	53.3	53.3
Nangmay.....	2426	China.....	45.3	56.7	30.0
India Hull-less.....	698	India.....	47.7	56.7	23.7
Unnamed.....	497	Egypt.....	50.3	56.7	32.8
Turbot.....	1254	do.....	51.0	56.7	61.2
Composite Cross selection (Oklahoma 35h9-9).		Selection from Composite Cross, C. I. 5461.....	41.7	60.0	55.8
Vance.....	4585	Selection from Smyrna, C. I. 2642.....	44.7	60.0	60.6
Yatlong.....	2464	China.....	45.3	60.0	23.0
Gumshu.....	5217	Chosen.....	47.3	60.0	13.5
Reed Triumph.....	889	Highland Chief X Mensury.....	47.7	60.0	60.7
Atlas X Vaughn (Moscow 33-31). ⁴	6975	Atlas X Vaughn.....	48.0	60.0	78.9
Han River.....	206	China.....	49.0	60.0	45.2
Olonets.....	198	U. S. S. R.....	49.3	60.0	66.8
Bozu.....	749	Japan.....	50.3	60.0	12.0
Khanaka.....	743	Turkestan.....	60.0	60.0	84.1
Atlas X Vaughn (Moscow 33-44).	6979	Atlas X Vaughn.....	46.3	63.3	67.5
Atlas.....	4118	Selection from Coast.....	47.3	63.3	40.7
Heron.....	1299	U. S. S. R.....	50.0	63.3	51.1
Composite Cross selection (Texas 1-33-179).	6500	Selection from Composite Cross, C. I. 5530.....	50.3	63.3	69.8
Composite Cross selection (Oklahoma 39-5254).		do.....	45.3	66.7	62.7
Kusan.....	1315	Egypt.....	48.3	66.7	57.5
Tenkow.....	646	Tennessee Winter X Hankow.....	48.7	66.7	59.5

¹ Estimate of leaves injured taken on 100 plants, 25 plants in each of 4 locations in plot.² Estimate of total injury of entire plot, including leaves injured and plants killed, by general observation of entire plot, based on percentage of nearest check plot.³ Estimate of plants killed, taken on 100 plants in center row of plots, after green bugs had disappeared and growth was resumed.⁴ Nursery number, in this table, and subsequently, at Moscow, Idaho.

TABLE 13.—*Green bug injury to winter barley varieties spring-seeded in 5-row 10-foot nursery plots in a triple-lattice design, Lawton, Okla., 1942—Continued*

Variety	C. I. No.	Origin or source	Leaves injured April 7 ¹	Total injury April 25 ²	Plants killed April 30 ³
Trebi.....	936	Asiatic Turkey.....	<i>Percent</i> 49.0	<i>Percent</i> 66.7	<i>Percent</i> 75.4
Composite Cross selection (Oklahoma 35h9-12).		Selection from Composite Cross, C. I. 5461.	53.3	66.7	83.7
Zamugi.....	5178	Chosen.....		66.7	60.1
Atlas X Vaughn (Moscow 33-11) ⁴ .	6972	Atlas X Vaughn.....	53.7	66.7	74.3
Blackhull.....	878	Abyssinia.....	56.7	66.7	65.4
Lico.....	6279	Lion X Coast.....	51.3	70.0	60.1
Weider.....	1021	Australia.....	51.7	70.0	65.2
Italiana 62 (Oklahoma 37-4342).			52.0	70.0	49.0
Blackhull 1180.....	6009	Selection from Blackhull, C. I. 878.	53.3	70.0	53.8
Cape.....	557		54.0	70.0	55.8
Composite Cross selection (Oklahoma 39-5255).		Selection from Composite Cross, C. I. 5530.	55.3	70.0	66.3
Perth.....	6025	Australia.....	56.7	70.0	71.7
Coast.....	626		60.0	70.0	74.6
Tennessee Winter 52.....	3543	Selection from Tennessee Winter.	62.3	70.0	78.7
Wisconsin Winter.....	519	Europe.....	62.3	70.0	62.2
Do.....	2159	Selection from Wisconsin Winter, C. I. 519.	65.0	70.0	82.1
Rice.....	742	China.....	54.0	73.3	80.4
Atlas X Vaughn (Moscow 33-27).		Atlas X Vaughn.....	55.0	73.3	77.6
Maison Carre X Flynn (36Ab5179).		Maison Carre X Flynn.....	55.7	73.3	63.9
Texan.....	6499	Selection from Composite Cross, C. I. 5530.	58.3	73.3	72.2
Tong.....	2462	China.....	59.0	73.3	74.4
Composite Cross selection (Oklahoma 39-5257).		Selection from Composite Cross, C. I. 5530.	60.3	73.3	59.7
California Mariout.....	1455	North Africa.....	61.7	76.7	82.5
Randolph.....	6372	Selection from farm field in North Carolina.	63.3	76.7	82.8
Lion.....	923	U. S. S. R.....	65.0	76.7	77.5
Phoebe.....	1305		65.7	76.7	90.4
Oderbrucker.....	940		72.7	76.7	86.8
Tennessee Winter 66.....	3546	Selection from Tennessee Winter.	75.7	76.7	72.6
Ramadan.....	2478	Algeria.....	55.3	80.0	89.1
Iredell.....	6571	North Carolina selection from Tennessee Beardless 6.	63.0	80.0	83.3
Unnamed.....	5088	China.....	63.3	80.0	88.1
Wintex.....	6127	Selection from farmer's field in Texas.	64.3	80.0	80.8
Tennessee Winter.....	6034	Virginia seed service.....	66.3	80.0	97.2
Composite Cross selection (Oklahoma 39-5245).		Selection from Composite Cross, C. I. 5530.	66.3	80.0	84.2
California Mariout X Lyallpur (36Ab5092).		California Mariout X Lyallpur.....	71.3	80.0	79.3
Zehra.....	5189	Chosen.....	75.3	80.0	88.4
Silver King.....	890	Manchuria.....	83.3	80.0	97.4
Reno.....	6561	Farm in Kansas.....	66.0	88.3	85.8
Missouri Early Beardless.....	6051	Selection from farmer's field in Missouri.	68.7	83.3	89.2
Keiroku.....	5240	Chosen.....	71.0	83.3	89.9
Michigan.....			71.7	83.3	82.1
Golden Pheasant X Hannchen (36Ab3896).		Golden Pheasant X Hannchen.....	88.3	90.0	98.6

¹ Estimate of leaves injured taken on 100 plants, 25 plants in each of 4 locations in plot.² Estimate of total injury of entire plot, including leaves injured and plants killed, by general observation of entire plot, based on percentage of nearest check plot.³ Estimate of plants killed, taken on 100 plants in center row of plots, after green bugs had disappeared and growth was resumed.

strains grown at Denton, Tex., and from both spring and fall seedings at Lawton, Okla., were Dobaku, Omugi, and Hoodless Beardless. Strains showing high resistance at Lawton from both fall and spring seedings but not grown at Denton include Rufino, Mignon, Bordo, Niver, and White Gatami. That green bug resistance is inherited and may be transmitted in crosses is evidenced by the high resistance of

Esaw, Sunrise, and Smooth Awn 86, all of which have a common parent, Nakano Wase, a Japanese barley. Several Gatami strains were highly resistant, and third generation bulk hybrids of Black Gatami \times Winter and Black Gatami \times Texan grown at Denton showed segregation for resistance, many plants surviving to mature normally.

For a study of resistance to chinch bugs, a spring planting of 136 varieties of barley was made at Lawton, Okla. This test consisted largely of spring barleys but included some winter types. Data on the reaction of these spring-sown strains to green bug attack are given in table 14. As with previous data, notes were taken on three dates,

TABLE 14.—*Green bug damage to spring-seeded barley varieties grown in single 5-row 10-foot nursery plots, Lawton, Okla., 1942*

Variety	C. I. No.	Origin or source	Leaves injured April 7 ¹	Total injury April 17 ²	Plants killed April 30 ³
			<i>Percent</i>	<i>Percent</i>	<i>Percent</i>
Hankow.....	192	China.....	23.4	11.1	0
Arlington Awnless.....	702	Tennessee Winter \times Black Arabian.....	41.7	17.0	0
Unnamed.....	5087	China.....	35.7	17.5	0
Do.....	5092	do.....	39.4	17.9	0
Tori.....	5246	Chosen.....	42.2	18.5	0
Dorshu.....	5154	do.....	38.5	18.9	0
Seibaku.....	5229	do.....	50.0	20.0	0
Peru.....	707	North Africa.....	35.0	22.2	4.8
Leopold.....	1057	China.....	33.3	24.6	11.1
Abvssinian.....	1231	Abyssinia.....	45.8	29.4	0
Telli.....	194	North Africa.....	44.8	33.3	61.2
Shonan.....	5255	Chosen.....	44.9	34.5	0
Wusein.....	1044	China.....	54.3	36.1	46.3
Yang Chung.....	1048	do.....	39.4	36.6	14.8
Amarillo.....	1073	do.....	38.6	39.5	7.1
Atlas \times Vaughn (Moscow 33-43).....	6978	Atlas \times Vaughn.....	55.8	40.4	78.0
Tripoli.....	1115	.....	41.0	42.1	72.1
Heil Hanna 4.....	677	Germany.....	55.1	43.5	78.0
Argentine.....	223	Argentina.....	55.7	44.4	74.5
Coast.....	691	North Africa.....	65.2	45.5	64.9
Atlas \times Vaughn (Moscow 33-13).....	6973	Atlas \times Vaughn selection.....	37.4	46.5	68.2
Colby 28445 \times Flynn (H. C. 33-2034).....	6983	Colby 28445 \times Flynn selection.....	56.6	51.0	79.1
Chukiang.....	1069	China.....	46.4	51.3	14.0
Hanseel Hull-less.....	703	Hankow \times hooded "b.".....	69.4	51.7	120.1
Peruvian.....	1131	Selection from Composite Cross, C. I. 5530.....	36.7	53.2	62.8
Canada Winter.....	713	Europe.....	56.2	53.6	5.6
Composite (Oklahoma 39-5260).....	.....	.....	45.0	55.6	95.3
Haua.....	734	India.....	74.5	55.6	71.1
Ghest.....	979	U. S. S. R.....	58.3	58.1	11.9
Moldavia.....	392	Rumania.....	66.0	58.1	100.4
Monte Cristo.....	1017	India.....	66.3	59.5	82.3
Lion \times Multan (36Ab5876).....	.....	Lion \times Multan.....	62.9	62.5	90.0
Kama-Ore.....	694	Japan.....	64.8	63.5	95.9
Italian 55 (Oklahoma 38-4360).....	.....	.....	57.1	64.5	86.0
Composite Cross selection (Oklahoma 39-5242).....	.....	Selection from Composite Cross, C. I. 5530.....	63.0	65.2	83.0
Composite Cross selection (Oklahoma 39-5247).....	.....	do.....	55.0	65.9	91.3
Memesh.....	593	China.....	72.9	66.7	81.8
Hooded 10.....	6563	Selection from Tennessee Beardless 6, C. I. 2746.....	77.5	66.7	82.6
Saitama-Nishiki.....	752	Japan.....	63.2	67.4	101.3
Odessa.....	182	U. S. S. R.....	67.7	68.5	87.0
Unamed.....	671	Abyssinia.....	101.7	69.4	136.6
Santol.....	2468	China.....	58.1	70.2	30.8
Woodrow.....	986	U. S. S. R.....	79.2	70.6	78.3
Atlas \times Vaughn (Moscow 33-8).....	6971	Atlas \times Vaughn.....	76.1	71.4	93.2

¹ Percentage injury based on inspection of 25 plants at each of four places in each plot, converted to percentage of nearest Michigan Winter check.

² Percentage of injury based on general appearance of entire plot, converted to percentage of nearest Michigan Winter check.

³ Percentage of injury based on inspection of 100 plants in center row of each plot, then converted to percentage of nearest Michigan Winter check.

TABLE 14.—Green bug damage to spring-seeded barley varieties grown in single 5-row 10-foot nursery plots, Lawton, Okla., 1942—Continued

Variety	C. I. No.	Origin or source	Leaves injured April 7 ¹	Total injury April 17 ²	Plants killed April 30 ³
Composite Cross selection (36Ab4961).		Selection from Composite Cross, C. I. 5461.	Percent 60.9	Percent 72.1	Percent 89.3
Abyssinia	362	Abyssinia	95.6	73.2	124.2
Club Mariout	261	Egypt	56.7	73.2	92.2
Sonbaku	5151	Chosen	64.2	74.1	19.6
Flynn 1	5911	Selection from Flynn, C. I. 1311.	77.3	75.0	102.6
Bano	2472	China	59.0	75.5	17.8
Glabron	4577	Smooth Awn × Man- churia.	60.6	76.9	86.5
Yanehadaka	580	Japan	78.5	76.9	101.6
Lopat	2477	China	80.8	76.9	54.1
Smooth Awn 86	6268	Tennessee Winter × Smooth Awn × Esaw.	79.4	76.9	81.0
Mensury	170	Manchuria	75.5	77.8	76.0
Tennessee Winter × Smooth Awn B5-14.	6570	Tennessee Winter 52 × Lion.	82.7	77.8	106.3
Composite Cross selection (Oklahoma 39-5265).		Selection from Composite Cross, C. I. 5530.	82.8	77.8	71.9
Jackson	6569	Tennessee Winter 52 × Lion.	86.8	77.8	102.2
Salamanca	689	Spain	96.7	77.8	100.0
Spartan	5027	Michigan 2 - Row × Black Barbless.	73.3	77.6	77.6
Eurylepis	2269	China	70.2	78.1	114.0
Unnamed	3883	Kashmir	77.1	78.4	116.0
Glacier	6976	Atlas × Vaughn	49.2	79.5	94.8
Banando	5210	Chosen	66.1	80.0	37.8
Bakson	5244	do.	69.6	80.0	37.7
Warabe	5205	do.	71.4	80.0	81.3
Shumaki	5222	do.	75.0	80.0	39.2
Sulu	1022	Australia	63.6	80.0	82.8
Nakano Wase	754	Japan	85.7	80.5	94.2
Caucasian	90	Caucasus	80.8	80.6	149.6
Composite Cross selection (Oklahoma 35h10-3).		Selection from Composite Cross, C. I. 5461.	67.0	81.1	96.5
Composite Cross selection (36Ab6308).		do.	90.5	83.3	104.6
Kentucky 11	6021	Tennessee Winter × Smooth Awn.	73.3	86.0	103.9
Unnamed	3921-2	Abyssinia	101.4	86.2	166.9
Turkestan (Winter)	711	Turkestan	78.5	87.7	144.5
Composite Cross selection (Oklahoma 39-5268).		Selection from Composite Cross, C. I. 5530.	96.2	88.6	103.1
North Carolina 11	6564	Selection from Composite Cross, C. I. 5461.	103.4	88.9	103.2
Reverse	2469	China	83.1	89.3	117.3
Caucasian	714	Caucasus	78.8	90.9	56.1
Santaku	5139	Chosen	82.8	90.9	101.2
Bodzu	753	Japan	111.1	90.9	100.0
Nipa	2471	China	81.1	92.6	57.0
Kentucky 2	6148	Selection from local Ken- tucky barley.	78.0	92.8	102.6
Union Winter	583	Europe	82.1	93.8	103.4
Michigan Winter	2036	Indiana Agricultural Ex- periment Station.	90.6	94.7	104.3
Kotsu	5161	Chosen	102.1	96.2	53.3
Wansnipe	2356	China	75.3	96.8	61.0
Composite Cross selection (Oklahoma 35h10-2).		Selection from Composite Cross, C. I. 5461.	114.6	97.2	124.2
Marnobarb	6120	Smooth Awn × Tennes- see Winter.	85.4	97.8	99.9
Hero	1286	Lion × Club Mariout	83.2	98.6	114.7
Cape	557	South Africa	111.7	98.8	124.1
Santiam	6367	Selection from Composite Cross, C. I. 5530.	111.5	100.0	111.0
Michigan Winter (21 checks).	7032	Oklahoma	100.0	100.0	100.0
Composite Cross selection (Texas 1-32-103).	6502	Selection from Composite Cross, C. I. 5530.	94.1	100.0	111.4
Kipo	5242	Chosen	71.4	100.0	17.6
Rangubori	5239	do.	80.4	100.0	101.4
Composite Cross selection (Oklahoma 39-5667).		Selection from Composite Cross, C. I. 5530.	92.0	100.0	112.2

¹ Percentage injury based on inspection of 25 plants at each of four places in each plot, converted to percentage of nearest Michigan Winter check.

² Percentage of injury based on general appearance of entire plot, converted to percentage of nearest Michigan Winter check.

³ Percentage of injury based on inspection of 100 plants in center row of each plot, then converted to percentage of nearest Michigan Winter check.

TABLE 14.—*Green bug damage to spring-seeded barley varieties grown in single 5-row 10-foot nursery plots, Lawton, Okla., 1942—Continued*

Variety	C. I. No.	Origin or source	Leaves injured April 7 ¹	Total injury April 17 ²	Plants killed April 30 ³
			<i>Percent</i>	<i>Percent</i>	<i>Percent</i>
Purdue 21.....	4581	Mass selection from Tennessee Winter.	104.1	101.0	100.8
Unnamed.....	3919-2	Abyssinia.....	127.5	101.7	171.9
Ward.....	6007	Local farm in Oklahoma.....	93.3	102.0	101.6
Blackhull 1178.....	5679	Selection from Blackhull C. I. 8787.	74.6	102.6	102.6
Milan.....	424	Asia.....	117.6	103.4	110.6
Minsturdi.....	1556	South African × Manchuria.	104.6	105.3	112.9
Eremo.....	2239	India.....	91.2	106.1	154.1
Tennessee Winter × Smooth Awn.....	6565	Tennessee Winter × Smooth Awn.	93.8	106.4	105.2
Peru.....	653	North Africa.....	113.1	106.7	124.6
Princess.....	529	Sweden.....	116.6	107.1	117.0
Pliter.....	6036	Selection from farmer's field in Michigan.	73.4	108.1	114.8
Ruble.....	870	Venezuela.....	95.9	108.7	102.7
Tambis.....	2470	China.....	84.6	109.1	172.4
Clemson Hooded.....	7042	South Carolina.....	115.9	111.1	111.9
Carytid.....	1108	Switzerland.....	119.4	111.1	132.8
Andie.....	728	India.....	117.6	113.2	248.4
Winter Club.....	1707	Europe.....	120.4	113.6	263.6
Hanna.....	226	Moravia.....	116.7	114.3	131.2
Poppenheim.....	314	Central Asia.....	126.3	115.4	132.1
Dinar.....	729	Tunis.....	90.0	115.4	256.7
Pontius.....	731	China.....	109.9	117.6	71.9
Winter Club.....	592	Europe.....	91.7	118.4	117.9
Barbary.....	695	North Africa.....	98.6	119.0	142.3
Tongukotsu.....	5211	Chosen.....	85.7	120.0	207.8
Dohadak.....	5187	do.....	112.5	120.0	263.5
Baku.....	253	Central Asia.....	122.3	121.6	120.9
Dehra.....	1085	India.....	130.7	121.6	130.0
Canadian Thorpe.....	740	England.....	191.4	125.0	322.1
Soqchow.....	867	China.....	115.6	127.7	273.7
Lokiang.....	2457	do.....	92.6	134.4	178.9
Poree.....	2428	Japan.....	119.9	135.6	178.5
Nugent.....	176	Swedish × Baxter.....	139.5	136.4	163.4
Manchuria.....	2330	Manchuria.....	111.9	139.5	169.2
Kharsila.....	733	Abyssinia.....	125.3	142.9	142.5
Abyssinian.....	1216	do.....	141.8	142.9	142.5
Kopeck.....	869	North Africa.....	104.0	146.3	328.9
Luth.....		Selection from farmer's field in Minnesota.	140.2	155.6	361.8
Galangatch.....	908	Chinese Turkestan.....	181.8	166.7	268.7
Pori.....	727	Chosen.....	156.0	176.5	340.4
	5184				

¹ Percentage injury based on inspection of 25 plants at each of four places in each plot, converted to percentage of nearest Michigan Winter check.

² Percentage of injury based on general appearance of entire plot, converted to percentage of nearest Michigan Winter check.

³ Percentage of injury based on inspection of 100 plants in center row of each plot, then converted to percentage of nearest Michigan Winter check.

recording (1) percentage of leaves injured on April 7, (2) total injury to the plot on April 17, by observation, and (3) percentage of plants killed on April 30, taken from a count of 100 plants as before. As not all these strains were located on the same area but were exposed to varying degrees of green bug infestation, all notes are expressed in percentage of the nearest Michigan Winter check plots.

The percentage of plants injured in the spring-sown test ranged from 11 of Michigan Winter check for Hankow to 176.5 of Michigan Winter check for Pori. It will be noted that some strains that showed high resistance when fall-seeded likewise showed high resistance when spring-seeded. Among those are Peru, Telli, Amarillo, and Argentine. Smooth Awn 86, which showed high resistance when fall-seeded, was damaged rather severely when spring-sown, although not so severely as many surrounding strains. The very high resistance of Hankow in comparison with several other varieties is shown in figure 9.



FIGURE 9.—High resistance of Hankow barley in comparison with other strains, Lawton, Okla., 1942: *a*, Mensury; *b*, Hankow; *c*, Hero; *d*, Composite Cross selection (36Ab6308); *e*, Odessa; *f*, Pliter; *g*, Michigan Winter; *h*, Jackson; *i*, Tennessee Winter \times Smooth Awn B5-14; *j*, Hooded; *k*, North Carolina 11; *l*, Santiam.

OAT VARIETIES

At Denton, Tex., where the green bug population was extremely large, no oat varieties were found that showed marked resistance to attack. The experimental tests included most of the commercial red oat strains in addition to many of hybrid origin.

At Lawton, Okla., where the insect population was the result of migration and the injury to the crop not so severe, some differences in injury were observed. Data on the reaction of varieties grown in field plots at Lawton are given in table 15.

TABLE 15.—Green bug leaf injury to oat varieties grown in triplicate field plots, Lawton, Okla., 1942

Variety	C. I. No.	Leaves injured			
		Replication			Average
		A	B	C	
		Percent	Percent	Percent	Percent
Tennex.....	3169	19	16	8	14.3
Fulwin.....	3168	22	14	12	16.0
Coker 33-47.....	3176	20	18	10	16.0
Fulgrain.....	3253	21	18	10	16.3
Coker 32-1.....	3026	25	20	9	18.0
Fultex.....	3531	17	21	17	18.3
Fulghum (winter type).....	2498	28	30	26	28.0
Do.....	2500	36	35	30	33.7
Wintok.....	3424	50	58	45	51.0

SPRING-SEEDED					
Columbia.....	2820	40	39	43	40.7
Ferguson 922.....	2150	46	51	52	49.7
Frazier.....	2381	39	59	56	51.3
Fulghum (Lawton seed).....		43	61	66	56.7
Texas Red Rustproof (T. S. 1415-12).....		48	65	62	53.8

From the data in table 15 it appears that there are some small differences among varieties of oats in their reaction to attack. The resistance observed is not of such a high order as was found in certain barley varieties, and under heavy infestation at Denton these same varieties were killed. Among the five varieties spring-seeded, the differences are relatively small and probably not significant. As some small differences were observed and as most of the varieties grown were of one type, it is possible that by growing a large number of varieties from world-wide sources greater resistance among oat varieties may be found.

ORIGIN OF RESISTANT VARIETIES

In recording the origin of varieties of barley grown at Denton, Tex., and Lawton, Okla., in 1942, it soon became apparent that the majority of the strains showing high resistance to green bug attack originated in the Orient, and by far the greater proportion of these came either from east-central China or from Chosen. The most resistant varieties reported in tables 10 to 14, inclusive, are grouped according to sources as follows:

China: Rufino*,⁶ unnamed (C.I. 5087)*, unnamed (C.I. 5092)*, Kunshan, Malwet, Nipa, Kumfide, Nunca, Hankow, Leopold, Nu Er Ta.

Chosen: Omugi*, Dorshu*, Seibaku*, Dobaku*, Sonbaku, Shumaki, Shonan, Kipo, Tori.

North America: Hoodless Beardless*, Wong, Esaw, Smooth Awn 86, Sunrise, Arlington Awnless, White Gatami, Gatami (Okla. 39-8004).

Union of Soviet Socialist Republics: Mignon.

Mesopotamia: Felix.

Abyssinia: Abyssinian (C.I. 1231).

Turkestan: Turkestan.

North Africa: Peru*.

In addition to the fact that the majority of the varieties showing high resistance originated in the Orient, it will be observed by studying the parentage of the North American resistant varieties in the original tables that oriental barleys appear as one of the parents in nearly all instances. Wong barley originated from the cross between Orel and a Chinese barley; Esaw, Sunrise, and Smooth Awn 86 all have a common parent in Nakano Wase from Japan. The Gatami strains are selections from Gatami barleys introduced from the Orient. From these facts it seems that resistant varieties must have been developed by natural selection over long periods in central China. The exact area where many of these originated is not known, but it is possible that many are related.

The fact that most of the resistant varieties of barley came from east-central China lends support to the moderate resistance observed in certain Chinese wheats reported in tables 5 and 6. Although it was thought that earliness of these wheats may have accounted for some of their resistance, nevertheless they survived much better than Tenmarq and other common varieties. Nanking No. 25 (P. I. 124270), Nanking No. 268 (P. I. 124322), Nanking No. 393 (P. I. 124340), and No. 12-13 (P. I. 118726) from China all were injured approximately 20 percent when adjoining plots of Tenmarq were injured 70 percent. By further testing of varieties from the Orient, as well as other world sources, it seems possible that high resistance to the green bug may be found in all the small grains.

* Varieties marked with an asterisk (*) appear twice in tables 10 to 14 as high-ranking varieties.

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